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AUTHOR Sweet, John F., Jr.: And Others
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ABSTRACT

This study investigated the ability of the Neonatal Behavioral Assessment Scale (NBAS), in combination with neonatal histories and developmental assessments, to predict mental and motor performance of 9-month-old infants on the Bayley Scales of Infant Development (BSID). Fourteen normal, full-term infants and 10 average-for-gestational-age, pre-term infants were studied. In all cases the NBAS assessments were completed when the infants were 40, 42, and 44 weeks gestational age. The BSID assessments were completed at 2, 4, 6, and 9 months gestational and chronological age for all infants. Also recorded at birth for all infants were Apgar scores, height and head circumference. Size and social-economic status of the family and birth order of the child were obtained via standard hospital procedures. Discriminate analysis yielded 100% of 9 month performance and pre-term or full-term group membership. NBAS subscales and neonatal histories provided three of four predictors of normal function and 11 of 11 predictors of abnormal function. (Author/SS)

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PREDICTION OF NINE MONTH PERFORMANCE FROM NEONATAL AND DEVELOPMENTAL CRITERIA

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Authors:

John F. Sweet, Jr., Ed.D., Psychologist,
Rockford Regional Perinatal Center
Rockford Memorial Hospital
Rockford, Illinois 61101
(815) 968-6861 Ext. 5060

Robert A. Karabinus, Ph.D., Professor
Department of Learning and Development
Northern Illinois University
DeKalb, Illinois 60115

Leonard K. Kise, Ed.D., Professor
Department of Learning and Development
Northern Illinois University
DeKalb, Illinois 60115

Correspondence to Senior Author-
Dr. Sweet at: 4765 Apollo Drive
Rockford, Illinois 61111
(815) 654-2807

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ABSTRACT

The present study investigated the ability of the Neonatal Behavioral Assessment Scale (NBAS), in combination with neonatal histories and developmental assessments, to predict mental and motor performance at 9 months on the Bayley Scales of Infant Development. Discriminate analysis yielded one hundred percent prediction of 9 month performance and pre-term or full-term group membership. NBAS subscales and neonatal histories provided 3 of 4 predictors of normal function and 11 of 11 predictors of abnormal function.

PREDICTION OF NINE MONTH PERFORMANCE FROM NEONATAL AND DEVELOPMENTAL CRITERIA

Prediction of future developmental performance on the Bayley Scales of Infant Development (BSID) (1) from neonatal parameters has found increased acceptance over the last fifteen years. Apgar scores (2) and Graham/Rosenblish Scale Scores (3) have been found to predict 8 month BSID developmental performance. The Neonatal Behavioral Assessment Scale (NBAS) (4) has been found to predict 10 week BSID mental quotients (5). The NBAS has been gaining wider acceptance as an instrument that measures neonatal neurological and behavioral functioning and since the NBAS has been found to predict 10 week BSID performance, further examination of its long-term predictive nature was natural.

It was the intent of the present study to determine if assessments of pre-term and full-term infants on the NBAS at 40, 42, and 44 weeks gestational age and assessments on the BSID at 2, 4, and 6 months gestational and chronological age would predict 9 month gestational and chronological age BSID mental and motor developmental performance.

Materials and Methods

Fourteen normal, full-term infants and 10 average for gestational age pre-term infants, who were residents of Winnebago County in Northern Illinois, were studied. Each infant was delivered in or transferred immediately after birth to Rockford Memorial Hospital, Rockford, Illinois. The average pre-term infant weight was 1937 grams and the average gestational age was 34 weeks by Dubowitz Criteria (6). The average full-term infant weight was 3554 grams. All full-term infants were

judged to be 40 ± 2 weeks of age. All full-term infants were judged to be appropriate for gestational age and pre-term infants were classified as small for gestational age, appropriate for gestational age, or large for gestational age (7). In all cases the NBAS assessments were completed when the infants were 40, 42, and 44 weeks gestational age. The BSID assessments were completed at 2, 4, 6, and 9 months gestational and chronological age for all infants. Also recorded at birth for all infants were Apgar scores, height and head circumference. Size of the family, birth order of the child, and Social Economic Status were obtained via standard hospital procedures.

The NBAS was used (note 1) to assess the performance of all infants at 40, 42, and 44 weeks of gestational age. The 40 week assessment for full-term infants was completed during the third day following delivery in the newborn nursery and the 42 and 44 week assessments were completed during the follow-up visits to the pediatrician's office. The 40, 42, and 44 week assessments, for pre-term infants, were completed in the High Risk Unit if the infant was still hospitalized; or in the out-patient clinic offices of Rockford Memorial Hospital. The twenty-seven behavioral items and the twenty neurological reflex items of the NBAS were interpreted by means of Brazelton's original scoring design (4). An a priori system of scoring dimensions (8) was used to group the 47 NBAS items into four subscales, (Subscale 1, orientation; Subscale 2, motoric responses; Subscale 3, habituation; and Subscale 4, response to stress).

Mental and motor development was assessed at 2, 4, 6, and 9 months of gestational and chronological age via the BSID. The assessments were completed in the pediatrician's office for the full-term infants and in the outpatient clinic examination rooms for the pre-term infants. All BSID testings yielded a single raw score for each of the mental and motor scales (Note 2).

Results

Table 1 lists the means and standard deviations of the three NBAS assessments and Table 2 gives the means and standard deviations of the four BSID assessments. Tables 3 and 4 give the Pearson product moment correlations of the pre-term infant NBAS assessments with the gestational and chronological age BSID assessments. Table 5 gives the Pearson product moment correlations of the full-term infants.

Table 6 presents the results of the discriminate analysis (Note 3) used to determine the predictability of infant group membership by neonatal and developmental information. One-hundred percent prediction was obtained, which means that given the information obtained one could correctly predict whether an infant was pre-term or full-term. Tables 7 and 8 present the most significant predictors ($p < .001$) obtained when a discriminate analysis was used to predict 9 month performance on the mental and motor scales of the BSID from the developmental parameters obtained at 40, 42, and 44 weeks and at 2, 4, and 6 months. An eighty percent level of expected function was used as the discrimination line between normal and abnormal function at each evaluation. All infants were grouped together and each evaluation time was considered both by the gestational and chronological ages of the infants. Lumping all infants together as a group and using a percent of expected function as a discrimination point allowed gestational age to be considered, in combination with all the other data, as a plausible cause of delayed development.

One-hundred percent prediction of 9 month performance was obtained at each chronological and gestational age evaluation. In addition, predictive patterns emerged across all evaluations. Predictors for normal chronological age <u>mental</u> performance were gestational age at birth and the infants' orientation skills at

TABLE 1

MEANS AND STANDARD DEVIATIONS ON THE FOUR SUBSCALES OF THE NEONATAL BEHAVIORAL ASSESSMENT SCALE AT 40 WEEKS, 42 WEEKS, AND 44 WEEKS GESTATIONAL AGE

	TESTING	Pre-Term (n=10) Mean	S.D.	Full-Term (n=14) Mean	S.D.
40 weeks of age	NBAS-Subscale 1	3.00	.00	2.79	.43
	NBAS-Subscale 2	2.00	.82	1.93	.48
	NBAS-Subscale 3	1.80	.63	1.71	.47
	NBAS-Subscale 4	1.20	.68	1.00	.00
42 weeks of age	NBAS-Subscale 1	1.80	.79	1.79	.43
	NBAS-Subscale 2	1.70	.68	1.43	.51
	NBAS-Subscale 3	1.40	.70	1.29	.47
	NBAS-Subscale 4	1.00	.00	1.00	.00
44 weeks of age	NBAS-Subscale 1	1.30	.69	1.07	.27
	NBAS-Subscale 2	1.20	.63	1.00	.00
	NBAS-Subscale 3	1.30	.48	1.00	.00
	NBAS-Subscale 4	1.00	.47	1.00	.00

TABLE 2

MEANS AND STANDARD DEVIATIONS OF BAYLEY SCALES OF INFANT DEVELOPMENT MENTAL AND MOTOR TESTS OF PRE-TERM AND FULL-TERM INFANT GROUPS AT TWO, FOUR, SIX, AND NINE MONTHS OF AGE

			Chronological Age Scores				Gestational Age Scores			
			Mental		Motor		Mental		Motor	
	Type	N	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
2 Mo.	Pre-Term	10	22.7	6.32	10.6	2.99	34.4	7.93	14.7	2.87
	Full-Term	14	28.7	1.38	13.5	.76	28.7	1.38	13.5	.76
4 Mo.	Pre-Term	10	41.0	7.65	16.4	2.50	56.3	9.71	20.2	3.36
	Full-Term	14	54.8	5.49	21.6	2.31	54.8	5.49	21.6	2.31
6 Mo.	Pre-Term	10	63.4	10.08	23.3	4.24	75.5	10.66	30.0	7.41
	Full-Term	14	77.8	3.68	30.4	2.50	77.8	3.68	30.4	2.50
9 Mo.	Pre-Term	10	80.0	11.98	32.7	8.22	89.2	7.91	38.2	6.84
	Full-Term	14	92.2	3.38	40.6	2.82	92.2	3.38	40.6	2.82

TABLE 3

GESTATIONAL AGE (GA) PRE-TERM INFANT GROUP (n=10) PEARSON CORRELATIONS OF NEONATAL BEHAVIORAL ASSESSMENT SCALE SUBSCALES AT 40 WEEKS, 42 WEEKS, AND 44 WEEKS AND THE BAYLEY SCALES OF INFANT DEVELOPMENT MENTAL AND MOTOR SCORES AT TWO, FOUR, SIX, AND NINE MONTHS

	BSID 2 Month		BSID 4 Month		BSID 6 Month		BSID 9 Month	
	Mental	Motor	Mental	Motor	Mental	Motor	Mental	Motor
NBAS-2 40 weeks	-.583*	-.617*						-.736**
NBAS-3 40 weeks		.576*					.608*	
NBAS-4 40 weeks					-.544*		-.719**	-.729**
NBAS-2 42 weeks					-.687**	-.711**	-.736**	-.683*
NBAS-2 44 weeks					-.544*		-.719**	-.729**
NBAS-4 44 weeks					.752**	.732**	.774**	.723**

* - significant at .05
** - significant at .01

TABLE 4

CHRONOLOGICAL AGE (CA) PRE-TERM INFANT GROUP (n=10) PEARSON CORRELATIONS OF NEONATAL BEHAVIORAL ASSESSMENT SCALE SUBSCALES AT 40 WEEKS, 42 WEEKS, AND 44 WEEKS AND THE BAYLEY SCALES OF INFANT DEVELOPMENT MENTAL AND MOTOR MOTOR SCORES AT TWO, FOUR, SIX, AND NINE MONTHS

	BSID 2 Month		BSID 4 Month		BSID 6 Month		BSID 9 Month	
	Mental	Motor	Mental	Motor	Mental	Motor	Mental	Motor
NBAS-3 40 weeks				.618*				
NBAS-4 40 weeks			-.598*	-.618*			-.616*	-.586*
NBAS-1 42 weeks	-.837***	-.650*						
NBAS-2 42 weeks	-.648*		-.711**	-.776**	-.813**	-.780**	-.852***	-.899***
NBAS-2 44 weeks			-.598*	-.618*			-.616*	-.586*
NBAS-4 44 weeks							.669*	.660*

* - significant at .05
** - significant at .01
*** - significant at .001

TABLE 5

CHRONOLOGICAL AGE (CA) AND GESTATIONAL AGE (GA) FULL-TERM INFANT GROUP (n=14) PEARSON CORRELATIONS OF NEONATAL BEHAVIORAL ASSESSMENT SCALE SUBSCALES AT 40 WEEKS, 42 WEEKS, AND 44 WEEKS AND THE BAYLEY SCALES OF INFANT DEVELOPMENT MENTAL AND MOTOR SCORES AT TWO, FOUR, SIX, AND NINE MONTHS

	BSID 4 CA Mental	BSID 4 CA Motor	BSID 6 CA Mental	BSID 4 GA Mental	BSID 4 GA Motor	BSID 6 GA Mental
NBAS-1 40 weeks			.459*			.459*
NBAS-1 42 weeks			.459*			.459*
NBAS-2 42 weeks	.499*			.499*		
NBAS-3 42 weeks	.474*	.671**		.474*	.671**	

* - significant at .05
** - significant at .01

TABLE 6

DISCRIMINANT ANALYSIS OF STATISTICALLY SIGNIFICANT
PRE-TERM AND FULL-TERM ASSESSMENT DATA

Discriminant Function	Eigenvalue	Relative Percentage	Wilks Lambda	Chi-Square	df	Significance
1	19766.04	100.00	.0001	118.70	20	.001

Actual Group	N of Cases	Predicted Group Membership Pre-Term	Full-Term
Pre-Term	10	N = 10 100.0%	N = 0 0.0%
Full-Term	14	N = 0 0.0%	N = 14 100.0%

TABLE 7

COMMON PREDICTORS OF NINE MONTH MENTAL PERFORMANCE

	CHRONOLOGICAL AGE		GESTATIONAL AGE	
AT:	NORMAL	ABNORMAL	NORMAL	ABNORMAL
6 Months	4 mo. Weight 40 wk. Habituation 42 wk. Habituation 44 wk. Orientation 6 mo. Chronological Mental	4 mo. Head Circumference 42 wk. Orientation 44 wk. Habituation 4 mo. Gestational Motor 6 mo. Chronological Motor	Size of Family Birth Order Birth Head Circumference 2 mo. ~~Birth~~ Head Circumference 44 wk. Responses to Stress 6 mo. Chronological Mental	1 min. Apgar 44 wk. Weight 44 wk. Head Circumference 40 wk. Motoric Responses 44 wk. Habituation
4 Months	Gestational Age at Birth 2 mo. Chronological Mental 2 mo. Gestational Motor 4 mo. Gestational Mental	2 mo. Chronological Motor 2 mo. Gestational Mental 4 mo. Chronological Mental	2 mo. Head Circumference	1 min. Apgar 44 wk. Head Circumference 40 wk. Motoric Responses 44 wk. Habituation 2 mo. Gestational Mental
2 Months	Gestational Age at Birth 44 wk. Orientation 44 wk. Responses to Stress		2 mo. Head Circumference	1 min. Apgar 44 wk. Head Circumference 40 wk. Motoric Responses 44 wk. Habituation 2 mo. Gestational Mental
44 Weeks	Gestational Age at Birth Social Economic Status 40 wk. Motoric Responses 40 wk. Habituation 44 wk. Orientation 44 wk. Responses to Stress	Sex 1 min. Apgar Gestational Age Group 42 wk. Motoric Responses ~~42~~ 44 wk. Habituation ~~44~~ 42 wk. Orientation 44 wk. Responses to Stress	Race Size of Family Birth Order Birth Head Circumference 40 wk. Habituation 42 wk. Motoric Responses 44 wk. Responses to Stress	Sex 1 min. Apgar Gestational Age Group 44 wk. Head Circumference 40 wk. Motoric Responses 44 wk. Orientation 44 wk. Habituation

TABLE 8

COMMON PREDICTORS OF NINE MONTH MOTOR PERFORMANCE

	CHRONOLOGICAL AGE		GESTATIONAL AGE	
AT	NORMAL	ABNORMAL	NORMAL	ABNORMAL
6 Months	Gestational Age at Birth 6 mo. Gestational Motor	Sex Race 4 mo. Head Circumference 2 mo. Chronological Motor 4 mo. Chronological Motor	Gestational Age at Birth 2 mo. Weight 2 mo. Gestational Motor	Sex Race 44 wk. Head Circumference 40 wk. Motoric Responses 40 wk. Habituation 44 wk. Orientation
4 Months	Gestational Age at Birth Social Economic Status 44 wk. Responses to Stress 2 mo. Chronological Mental 4 mo. Gestational Mental	Race 44 wk. Head Circumference 2 mo. Gestational Motor 4 mo. Chronological Mental	Gestational Age at Birth 2 mo. Weight 2 mo. Gestational Motor	Sex Race 44 wk. Head Circumference 40 wk. Motoric Responses 40 wk. Habituation 44 wk. Orientation 2 mo. Chronological Mental
2 Months	5 Min. Apgar 40 wk. Orientation 44 wk. Orientation 44 wk. Habituation	Race 42 wk. Orientation 42 wk. Motoric Responses	5 Min. Apgar	Sex 1 Min. Apgar 40 wk. Motoric Responses 42 wk. Motoric Responses 42 wk. Habituation 44 wk. Responses to Stress
44 Weeks	Gestational Age at Birth Social Economic Status 40 wk. Orientation 40 wk. Motoric Responses 44 wk. Orientation 44 wk. Responses to Stress	Sex Weight at Birth Race Size of Family 42 wk. Motoric Responses	Weight at Birth 5 Min. Apgar Social Economic Status Size of Family Gestational Age Group 44 wk. Weight 42 wk. Habituation 44 wk. Responses to Stress	Sex 1 Min. Apgar Race Birth Head Circumference 44 wk. Head Circumference 40 wk. Motoric Responses 40 wk. Habituation 44 wk. Orientation

44 weeks. No predictors emerged for abnormal mental performance. One predictor emerged for normal gestational age mental performance; head circumference at two months. Four predictors emerged for the abnormal group; apgar score at 1 minute, head circumference at 44 weeks, motoric responses at 40 weeks, and habituation at 44 weeks.

The predictor for normal chronological age motor performance was gestational age at birth. Race was the predictor of abnormal performance. There were no predictors of normal gestational age motor performance. Predictors of abnormal motor performance were sex, race, head circumference at 44 weeks, motoric responses at 40 weeks, habituation at 40 weeks, and orientation at 44 weeks.

Discussion

The results of this study have indicated that an a priori scoring system of the NBAS in combination with an infant's gestational age, weight, and head circumference at birth, apgar scores, demographic data and 2 month developmental evaluation on the BSID, can predict 9 month BSID performance. Two subscales of the NBAS, orientation at 44 weeks and habituation at 40 weeks, were found predictive of both normal and abnormal function at various times. When an infant exhibited rapid habituation at 40 weeks, he was found more likely to do well on the 9 month chronological age BSID mental scale. This held true when only the neonatal data was considered and when all data through 2, 4, and 6 months was considered. Poor habituation was indicative of poor 9 month gestational age BSID motor scale performance.

This was true for neonatal data only, and when all data through 4 and 6 months was considered.

The predictive qualities of the 44 week orientation skills were somewhat more complex. In the main, good orientation skills predicted good chronological age mental and motor performance at 9 months. This was true at 44 weeks and 2 months for the motor score and at 44 weeks, 2 and 6 months for the mental score. Poor 44 week orientation skills were predictive of poor motor performance at 9 months. This was found at 44 weeks and at 4 and 6 months.

Except for the two discrepancies previously noted, all other NBAS subscales were predictive in only one direction. Other predictors of normal 9 month chronological age function were orientation at 40 weeks (motoric function), Social Economic Status (motor) and responses to stress at 44 week (mental and motor function). Additional predictors of abnormal chronological age function at 9 months were orientation (mental) and motoric responses (motor) at 42 weeks, sex (motor), and habituation (mental) at 44 weeks. Abnormal gestational age function was also predicted by the 2 month gestational age mental score (mental). Additional normal gestational age predictors were size of family (mental), birth order (mental), birth head circumference (mental), responses to stress at 44 weeks (mental), gestational age at birth (motor), 2 month weight (motor) and gestational age motor score (motor), and the 5 minute apgar score (motor).

Only 1 of the 4 predictors of normal 9 month performance was obtained after the final neonatal assessment. Head circum-

ference at 2 months was predictive of mental function. None of the 11 predictors of abnormal 9 month performance was obtained after 44 weeks. Thus, by far, most of the predictive information in this study was found within the first 4 weeks of life. If this trend holds true with larger samples, it should provide further verification of the usefulness of the NBAS as an effective evaluation device. In addition, verification should also show the ability of the NBAS to predict, with birth data, later developmental performance. If this verification is forthcoming, it would allow caregivers to detect and/or monitor potential developmental problems at earlier ages.

Neonatal assessments, birth histories, and subsequent evaluations of developmental performance were predictive of 9 month mental and motor performance on the BSID. In all cases common predictors emerged which provided an indication of the stability of the neonatal parameters across the 9 month period. Such stability, if found with larger sample sizes, should enable physicians and pediatric psychologists to monitor closely; at less frequent intervals, fewer specific details of infant development. Such less detailed and less frequent intervention would cut care costs, while not decreasing the quality of service. Such evaluations would continue to allow for early interventions when needed, and most importantly, would provide quick and accurate assessments of current performance while predicting the future outcome of that infant.

Follow-up studies would indicate the reliability of the NBAS as a predictive instrument over longer time periods. Such studies would enhance the use of the NBAS as a predictive instrument and encourage its use as a normal pediatric practice.

Reference Notes

Note 1 - Reliability obtained by principle investigator in Boston, Massachusetts at Children's Hospital in March, 1978.

Note 2 - All testings were completed by the principle investigator.

Note 3 - The Statistical Package for the Social Sciences version 8 of discriminate analysis was used.

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